Directly Determined Properties of Exoplanet Host Stars

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(Essential) Motivation

You only understand the exoplanet
only as well as
you understand the parent star

(if you are lucky)

Directly Determined Properties

of Exoplanet Host Stars

- "Properties": stellar radius, T_{eff}, L
- "Direct":
    - optical & NIR interferometry (θ)
        - CHARA Array (uniform disk, angular diameter)
        - Limb-darkening corrections (Claret+2001,2011)
    - trigonometric parallax (distance → radius)
        - Hipparcos, RECONS, …
    - SED fitting (F_{BOL} & θ → T_{eff}, L)
        - Literature photometry measurements
        - Updated filter profiles (Mann & von Braun 2015)

Products & Applications

- Largely empirical stellar astrophysical parameters (L, R, T_{eff})
- Exoplanet system characterization (size and density for transiting planets, HZ, etc.)
- Stellar physics, particular late-type stars (Boyajian+2015)
- Calibration / constraints for stellar models
- Predictive, semi-empirical relations for stellar R & T_{eff} as functions of observables (Boyajian+2013, Mann+2015, Adams+2017, etc.)

Why "direct"?

- SB Law: $T_{eff} \sim (L\ R^{-2})^{0.25} \sim (F_{BOL}\ \theta^{-2})^{0.25}$
- Common approaches:
  - Full-on stellar models
  - Semi-empirical: determine T_{eff} spectroscopically, SED fitting for F_{BOL}, get θ and R_{star}.
  - NB: Interferometric results calibrate models & relations.
- Where direct interferometry/SED approach helps:
  - Stellar models tend to underestimate stellar radii (5-10%) and overestimate T_{eff} (3-5%), especially for (early and) late spectral types.
  - For semi-empirical models, σT_{eff} of 3-5% result in $\sigma R_{star} \sim$ 6-10%.
  - Accuracy, eccentric objects, …

Direct does not mean easy

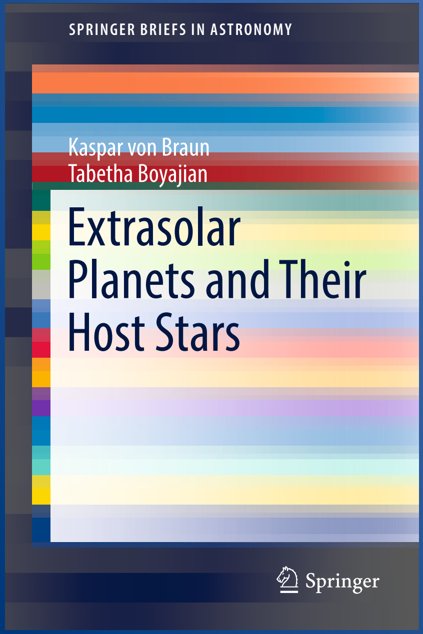
- Interferometry is difficult.
  - Atmospheric conditions; time scales.
  - (Un)known calibrator sizes; choice of calibrators.
  - Uncertainties very hard to characterize.
  - Inherently complicated method (systematics).
- SED can be affected by
  - Unknown errors in literature photometry
  - "Incorrect" filter profiles.
  - Misclassification, …

Empirical HRD
(~ 300 stars)

size of data point
= log R_{star}

Blue: EHS (~60)

- Status Nov 2016
- $\delta\theta < 5\%$
- d < 150 pc
- R < 100 R_{solar}
- no fast rotators
- no pulsators



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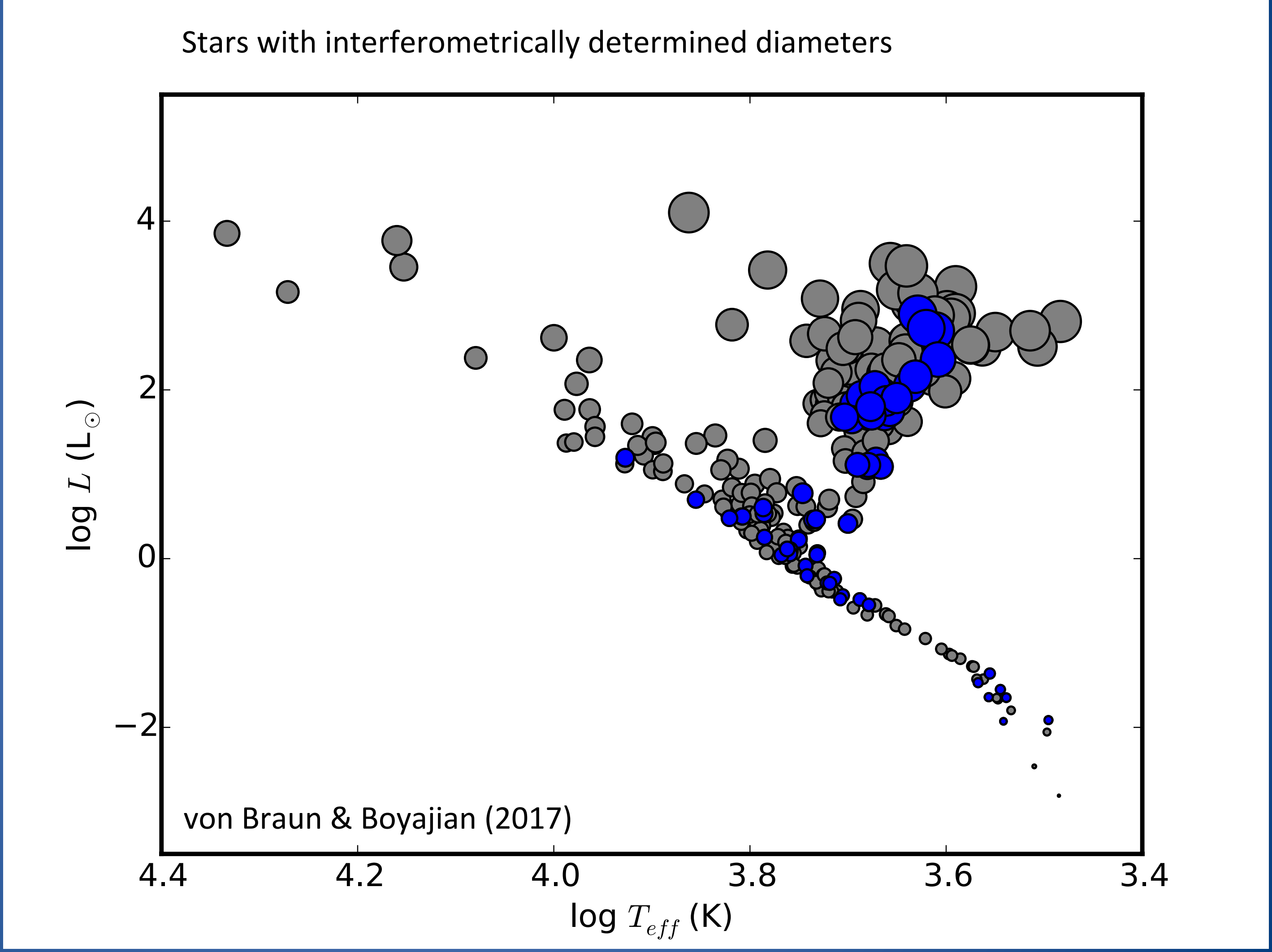
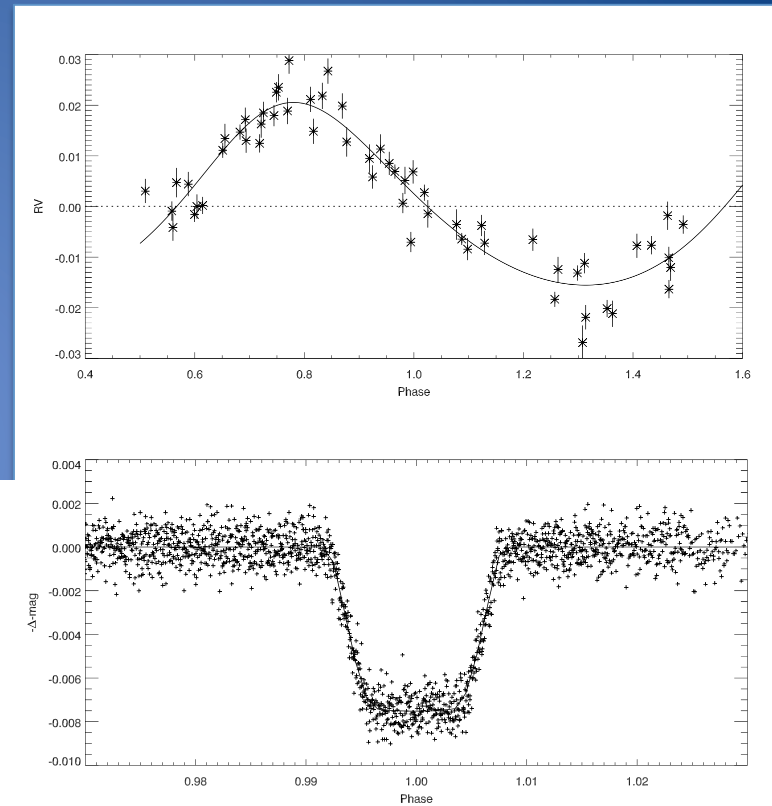
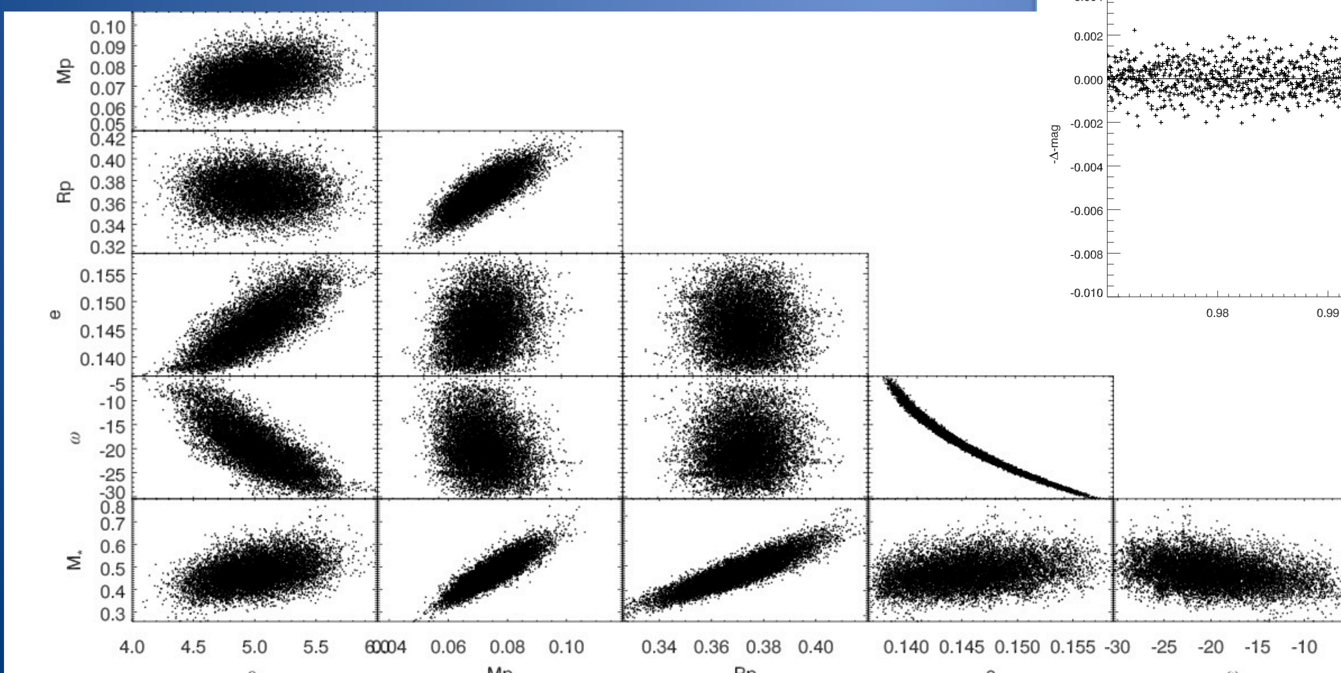


Selected Highlight 1/3 – GJ 436

Combine interferometry with literature time series photometry and RV data.

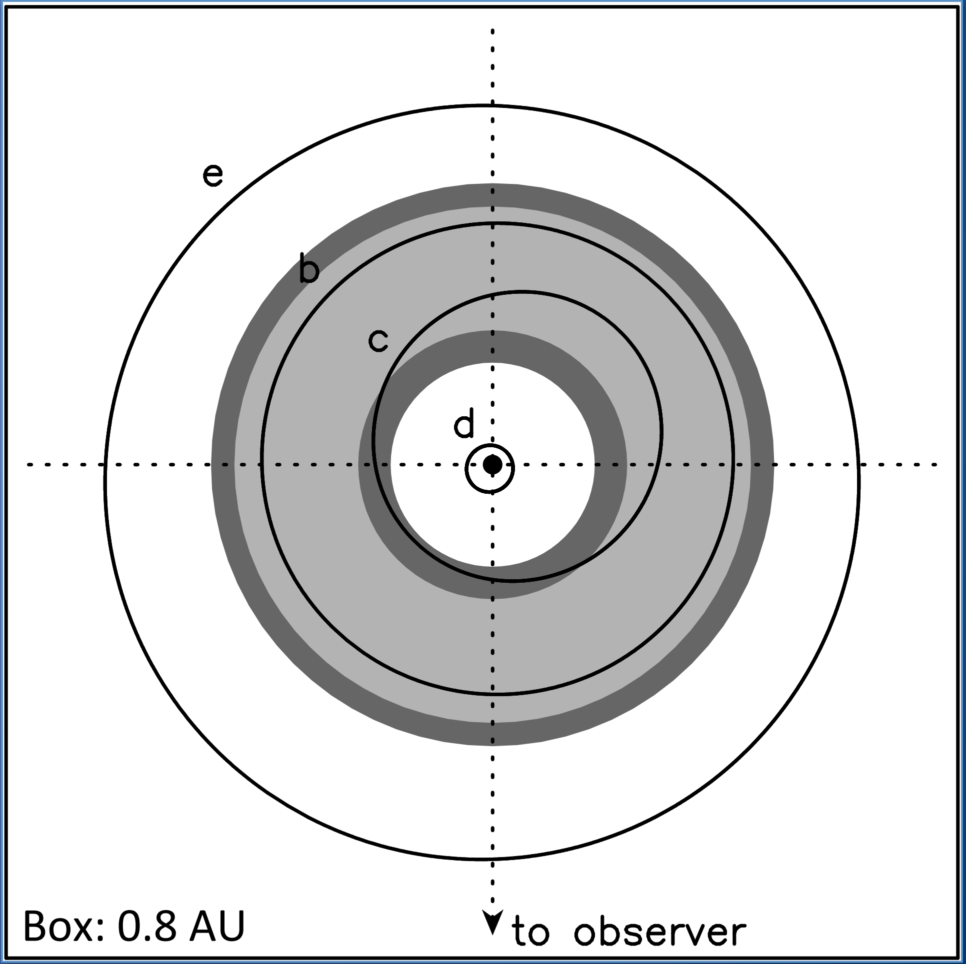


von Braun et al. 2012



Selected Highlight 2/3 – GJ 876

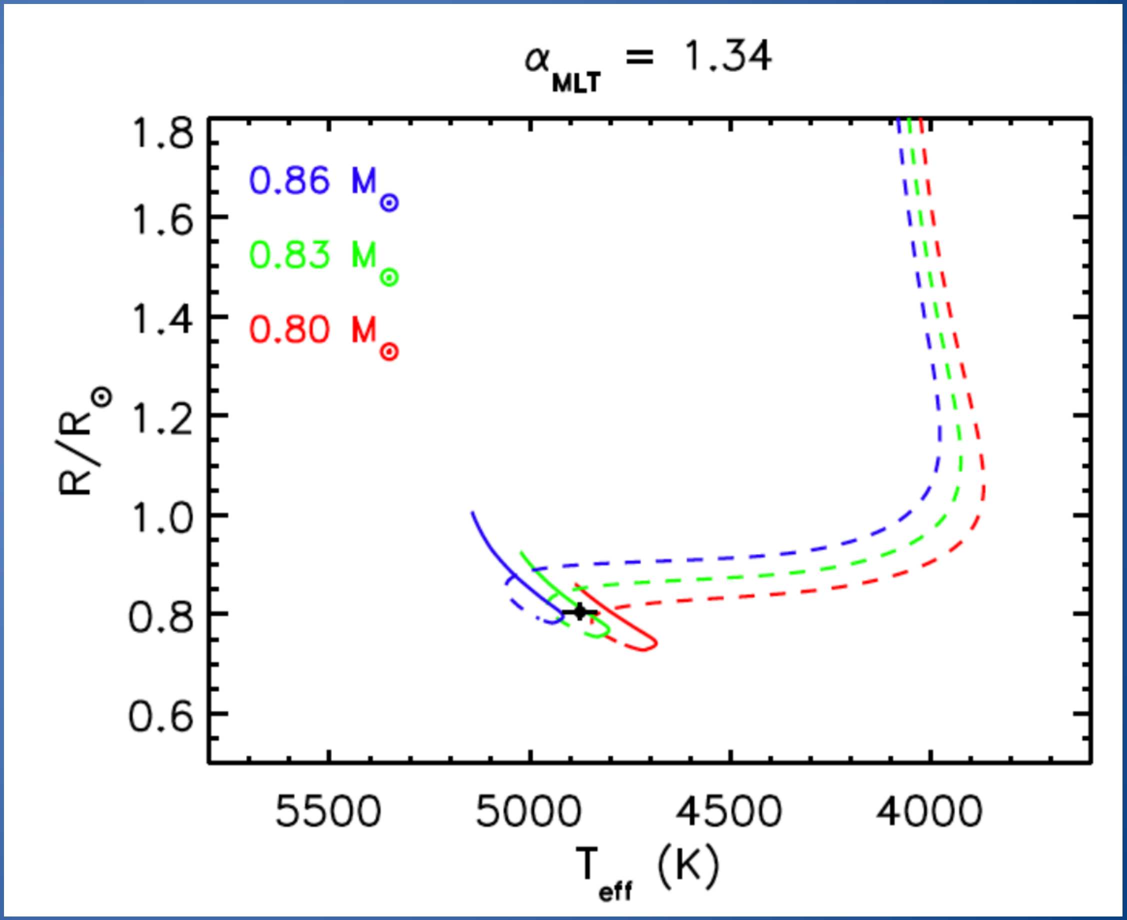
Interferometric radius ~ 25% (>12σ) larger than literature values.



von Braun et al. 2014

Selected Highlight 3/3 – HD 189733

Interferometric radius can be harmonized with models for different value of mixing length parameter (but not for different age, composition, magnetic activity, etc.)



Boyajian et al. 2015